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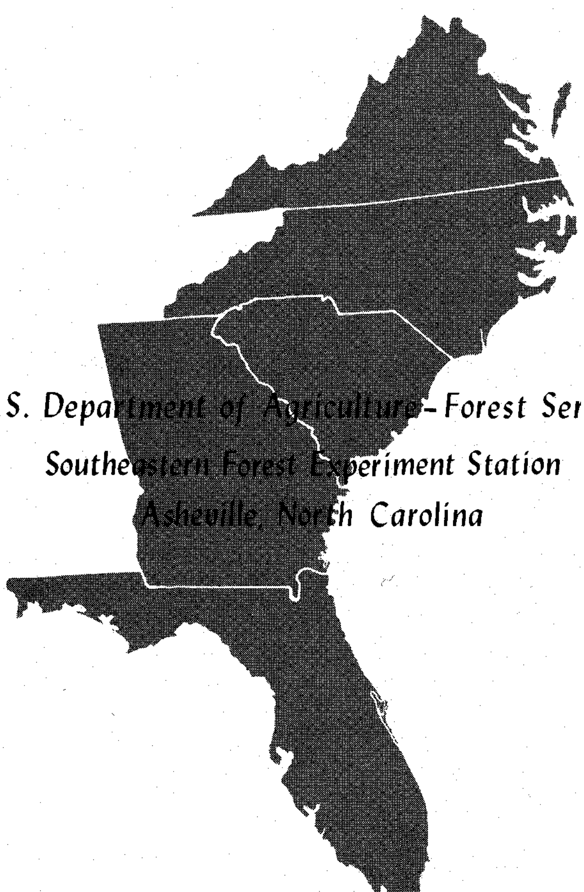
Annotated Bibliography of Publications on Watershed Management by the Southeastern Forest Experiment Station, 1928-1970



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Annotated Bibliography of Publications on Watershed Management by the Southeastern Forest Experiment Station, 1928-1970

by

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INTRODUCTION

This Bibliography was prepared at the request of scientists, educators, students, and land managers seeking information on published results of research on watershed management by the Southeastern Forest Experiment Station. It contains 209 annotated citations of publications on watershed management and the influence of various types of forest cover on streamflow and water yield. All authors listed were staff members of the Station or individuals whose research was supported either in part or entirely by the Station. The Bibliography covers publications issued from 1928 through 1970 and includes some that appeared in early 1971.

The citations are arranged alphabetically and chronologically by author. An asterisk (*) before the citation number indicates that reprints of the publication can be obtained from the Southeastern Forest Experiment Station as long as the supply lasts. As would be expected, a variety of types of papers are involved. These include discussions of research problems and needs; reviews of research programs, objectives, and results; descriptions of instrumentation, analytical procedures, and experimental areas; reviews of research results from different geographical or technical fields; and presentation of results of original research. Immediately preceding the Bibliography is a Subject Index in which each citation is keyed by number to the subject category under which it falls. Some citations have been cross-referenced under several categories.

Recency of publication is not a sure indication of the relevance of the work to contemporary research. In some cases, earlier published results have later been superseded by more complete reports, but some of the earlier reports dealing with analytical procedures, methods, and, in particular, descriptions of the hydrologic functioning of forested watersheds are still classic works in forest hydrology.

Because the emphasis in watershed management has shifted with the changing needs and problems of the times during the 50 years of the Station's existence, a brief historical survey of the program is included for the interested reader. Dr. Charles R. Hursh, who directed this research program at the Station for many years, provided valuable information on the early history of forest hydrology in the Southeast, and his assistance is gratefully acknowledged.

SURVEY OF WATERSHED MANAGEMENT RESEARCH

Interest in forest influences on the environment in the Southeast began before the first decade of this century, when there was much verbal speculation about the effects of forests on climate and public health and on soil and streamflow. Editors and writers discussed these subjects with little or no consideration for accurate technical terminology. The U. S. Army Engineers, who had charge of flood control and levee operations, were critical of such writers, particularly when they made broad, unsupported statements about the effects of forests on streamflow. In a widely read government publication issued in 1909, Major-General Chittenden of the Mississippi River Flood Control project expressed himself forcibly that forests were of no significance in flood control. Then came the Weeks Act of 1911, which led to the creation of the National Forests, and further controversy that reached a high pitch at the time of the disastrous 1927 flood on the Mississippi River. Almost everything written on the favorable effects of forests on streamflow was being questioned.

On July 1, 1921, the Appalachian Forest Experiment Station, later renamed the Southeastern Forest Experiment Station, was established. Its research program was oriented primarily toward study of silviculture, reforestation, and management of forests, as well as forest protection, forest economics, and streamflow and erosion control, although active research in the latter did not begin until 1926.

At that time, livestock was being grazed extensively in the eastern National Forests. Steep mountain land everywhere was being cleared and planted with corn. Logging was done by subcontractors who had little regard for resulting damage to the forest or erosion from skid trails. Local farmers considered pine trees as weeds; depleted and abandoned fields in "broom sage" were called "pastures." Erosion on wornout and abandoned land in the Southeast was regionwide. Such land was not wanted by private individuals and could be bought for delinquent taxes. Nevertheless, the rank and file of professional foresters at the time were not informed on the subject of forest effects on climate and soil, and they were completely inarticulate on the subject of streamflow in terms of total water yield, maximum peak discharge, or minimum flow dependability.

Fortunately, E. N. Munns, of the Forest Service's Branch of Research, had observed and written about land erosion in California prior to his assignment to Washington. Supported by E. H. Clapp, then Chief of Forest Research, Mr. Munns became an effective advocate of better land use and of more in-depth research into forest influences on water yield. He believed that a start could be made through studies relating soil conditions to infiltration and surface stormflow. The Branch of

Research requested a Civil Service examination for ecologists with Ph. D. degrees, and two successful applicants were selected. Dr. Hursh was employed by the Appalachian Station in 1926 and actively directed the Division of Forest Influences until his retirement in 1954.

The first goal of this research program was to define the characteristics of the soil, water, and climate of forested land in the Southern Appalachians. At the time, there were no continuous data on streamflow from small drainages selected as independent hydrologic units, and work was begun to obtain valid data suitable for hydrologic analysis.

Some of the earliest work dealt with erosion control and methods of soil stabilization along roadbanks and on abandoned agricultural land and with study of forest humus types of the region. At the Bent Creek Experimental Forest, plots were established in 1932 to study surface runoff from five representative types of forested or agriculture cover, and an infiltrometer was first used successfully with artificial rainfall. These early studies led to an examination of water movement through the soil profile and to the need for complete watershed instrumentation to provide continuous measurements of streamflow and precipitation.

Dr. Hursh was detailed to visit existing Forest Service installations of lysimeters in operation in the Western States. On the basis of this experience, he sought to locate suitable areas on which the Appalachian Station could conduct comprehensive studies on watershed management. Mr. John Byrne, Forest Supervisor of the Nantahala National Forest, suggested a number of possible sites, and the Coweeta drainage basin near Franklin, North Carolina, was finally selected as the most suitable. In 1933, 3,900 acres (later increased to 5,750 acres) of the Nantahala National Forest were set aside as the Coweeta Experimental Forest. After Station Director C. L. Forsling issued instructions that no manipulations of the forest cover were to take place at Coweeta until after a period of standardization of the gaged watersheds, full responsibility for administration of the Coweeta basin was assumed by the Division of Forest Influences.

Thus, the stage was set for a greatly expanded program in watershed management. It was the programs of the Civilian Conservation Corps and the Public Works Administration during the depression years which provided the manpower and funds for expansion of research activities. At Coweeta, a CCC camp was established at the entrance of the basin, and an intensive program of weir construction was started in 1934. A network of 56 standard rain gages and numerous ground-water wells were established in the basin, and a period of watershed calibration began.

Although no staff appointments were made from the Civil Service register during the years the watershed work at Coweeta Experimental Forest was being established, any properly qualified person could be paid from emergency funds for a 3-month temporary period, and the assignment could be repeated indefinitely. Thus, it was possible to employ a number of graduates in engineering with training in hydrology. Some men with good research ability worked with the project under these terms for several years, and many of these men later rose to positions of importance in their profession.

At Bent Creek Experimental Forest during 1933 and 1934, eight weirs were constructed on watersheds ranging in size from 11 to 774 acres in order to study streamflow on areas with various types of cover. The areas studied included forested, mixed forested and agricultural, abandoned agricultural, and overgazed pasture land. At Bent Creek, the striking differences in peak discharge from abandoned old fields and overgrazed pastures as compared with forested watersheds were so consistent that no further measurements were required after the first few years. Data were put to work immediately by TVA in providing valid coefficients of storm runoff for different types of land use.

A unique opportunity to study modifications in local climate and streamflow as a result of removal of the forest cover presented itself at nearby Copper Basin, Tennessee. There, sulfur dioxide fumes from open-hearth smelting of copper ore had killed extensive areas of native forests in the 1800's--one of the earliest and best known examples of air pollution in the Southeast. Death of the forest had created three concentric zones in the basin. The center was completely denuded and severely eroded. A belt of grassland surrounded this zone, and, in turn, the grassland merged with the native forest. Three meteorological stations were installed in 1935, and three more were installed in 1936. Two watersheds were gaged in each zone, and records were collected from 1935 until 1940. Forest Service activities were terminated in 1940, although TVA continued meteorological observations at Copper Basin for several more years.

By 1940, calibration of watersheds at Coweeta was far enough along on some catchments to begin treatments, and a period of experimentation began. Since 1940, watershed experiments have been conducted at Coweeta. Documentations have been made of the harmful effects of certain land-use practices, such as mountain farming, woodland grazing, and unrestricted logging, on soil and water resources. Water-yield experiments designed to measure effects on streamflow of complete or partial forest cuttings and conversion from one type of cover to another have provided conclusive evidence that water yield is influenced by the type and characteristics of the vegetative cover. The knowledge gained in these early experiments later served as a basis for a pilot test of intensive multiresource management of Southern Appalachian forests and has provided guidelines for watershed management on public and private land alike.

By 1945, the primary objectives at Bent Creek had been fairly well achieved, and, because of a lack of manpower and funds for the area, watershed management studies were terminated there. The following year, the 12,000-acre Calhoun Experimental Forest near Union, South Carolina, was set aside for study of the relationships between forests, soils, and streamflow in the agriculturally depleted and severely eroded Piedmont. These studies were aimed at restoring and maintaining favorable conditions for water storage in the soil profile, stabilizing soils and revegetating barren, eroding gullies, inventorying water use and storage of soil moisture by typical vegetative cover types, and determining the, effect of different forestry and related land-use practices on the volume, quality, and timing of streamflow. Four small watersheds were instrumented in 1950 and were operated for 12 years. In 1962, the soils project at Calhoun was transferred to the new Forestry Sciences Laboratory at Research Triangle

Park, North Carolina, and the research concerned with watershed management was consolidated with and centered at the Coweeta Hydrologic Laboratory.

The same year, watershed management activities in the Southeast were extended into the Coastal Plains, where there are millions of acres of wetland forests comprised of swamps, wet flats, bays, and bottom lands. Once viewed as a curse to the roadbuilder and logger trying to extract timber, these wetland forests are now recognized as major sources of water, wildlife, timber, and recreation in the Southeast. Knowledge of the hydrologic and other environmental consequences of management of wetlands was required in order to improve water management practices in wetland forests, and a research project on Wetland Forest Soil Improvement was established at Charleston, South Carolina. Four weirs were established to gage flow from 400- to 11,000-acre wetland drainages, and ground-water levels are now monitored at 30 shallow wells on the Santee Experimental Forest near Moncks Corner, South Carolina.

Watershed management research in the Southeast is currently underway at the Coweeta Hydrologic Laboratory and at Charleston. The mission of the Coweeta program is to develop sound principles and prediction methods to guide effective management of Southern Appalachian and Piedmont watersheds for improved water yield and for protection of environmental quality. The mission of the wetlands research program is to develop effective and reliable techniques of water control and soil management for wetland forests. Major problems of the wetlands are to define the hydrology of major physiographic wetland types and to determine the effects of water control measures and vegetative manipulation on hydrology and soil properties.

SUBJECT INDEX

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1951. The Coweeta story. Farmers Fed. News 31(12): 9, 44-45, 48.

Reasons for establishment of the Coweeta Hydrologic Laboratory are given, the research area is described, and studies concerning the effects of mountain farming, woodland grazing, and cutting of vegetation on streamflow are discussed.

(2) ________
1953. Woods grazing may be bad. Prog. Farmer Ga.-Ala.-Fla. Ed., January, p. 111.

Cattle gains, vegetative growth, and soil relations on a forested Appalachian watershed after 11 years of cattle grazing are reviewed.

(3) ________
1956. We learn about little waters of Coweeta. Forest Farmer 16(2): 20-21.

Experiments at Coweeta are pictorially described.

(4) Bay, R. R., and Klawitter, R. A.
1964. What's new in wetland hydrology. Soc. Am. For. Proc. 1963: 175-1'77.

A discussion is presented on wetland forests, their use, and Forest Service research efforts underway in the southeastern Coastal Plain and the Lake States.

(5) Bennett, J., and Fletcher, P. W.
1947. Loblollies and the land. Soil Conserv. 13(5): 115.

Survival, diameter, height, and volume of loblolly pine near Waterloo, South Carolina, were directly related to land classes based partially on soil differences; the better the land classes, the better the growth.

(6) Biswell, H. H., and Hoover, M. D.
1945. Appalachian hardwood trees browsed by cattle. J. For. 43: 675-676.

Cattle are selective in the tree species they browse. Percentage breakdowns by species are given for the foliage eaten by cattle on a 145-acre Appalachian watershed during 1941 and 1942. Herb utilization approached 100 percent after 1 year of grazing, and the grazing capacity of the watershed was reduced by 50 percent during 1 year of browsing.

(7) Black, P. E.
1957. Interception in a hardwood stand. M. F. Thesis, Univ. Mich. Sch. Nat. Resour., 90 pp.

Gross rainfall, throughfall, stemflow, and interception of rainfall by selected yellow-poplar and hickory trees were measured at the Coweeta Hydrologic Laboratory for 1 year. Equations are presented for predicting stemflow from gross precipitation and crown area and for predicting throughfall from gross precipitation. Throughfall for the year was about 73 inches, and gross precipitation was 82 inches. For unknown reasons, trees tended to segregate into two groups in relation to stemflow, one group yielding almost double the stemflow of the other.

(8) Black, P. E.
1959. Interception of rainfall by a hardwood canopy. Univ. Istanbul, Orman Fak. Derg., Ser. A, 9(2): 218-224.

Results of studying rainfall intercepted by cove hardwoods growing on an old field are discussed, and equations for determining throughfall during fall, winter, spring, and summer are presented. Estimates of the number of throughfall gages required for interception studies in similar stands are given.

*(9) ________ and Clark, P. M.
1958. Timber, water, and Stamp Creek. USDA Forest Serv. Southeast. Forest Exp. Stn., 12 pp.

This illustrative brochure outlines the proper logging techniques used in a timber sale on the Chattahoochee National Forest, Stamp Creek, Georgia. A satisfactory profit was realized by the logger without serious erosion or damage to the streams and fish.

(10) Boyer, J. S., and Knipling, E. B.
1965. Isopiestic technique for measuring leaf water potentials with a thermocouple psychrometer. Natl. Acad. Sci. Proc. 54(4): 1044-1051.

This new technique for determining rate of vapor flux between thermocouple and leaf is free of error caused by leaf resistance. The method can be used to measure leaf resistance directly and gives more accurate measurements of water potential than do other methods.

(11) Brater, E. F.
1937. An application of the unit hydrograph principle to small watersheds. Ph. D. Thesis, Univ. Mich., 56 pp.

Conversion of unit hydrographs from 22 Appalachian streams to a composite distribution graph with a common time base revealed that the graphs from the various watersheds varied considerably in shape; peak runoff percentage and basal width of the graphs were related to watershed area, and the effect of vegetative cover on runoff was pronounced. Pluviographs from three streams indicated that the composite distribution graphs are a true reflection of the runoff to be expected from a watershed. Study of rainfall intensity and time required for stormflow to recede indicated that variations in intensity have greater effect on lightly vegetated than forested areas. The effect of previous rainfall on stormflow decreased with time on grassy and forested watersheds, the effect being greatest on the latter.

(12) ________
1939. The unit hydrograph principle applied to small watersheds. Am. Soc. Civ. Eng. Proc. 65: 1191-1215.

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(13) Craddock, G. W., and Hursh, C. R.
1949. Watersheds and how to care for them. U. S. Dep. Agric. Yearb. 1949: 603-609.

Hydrologic principles related to forest land use as well as forest protection and management practices which influence the amount, quality, and timing of flow from forest land are discussed.

(14) Croft, A. R., and Hoover, M. D.
1951. The relation of forests to our water supply. J. For. 49: 245-249.

The authors use research findings to show how forest management practices affect the quality, quantity, and timing of water yield and discuss practical implications of forest management on the solution of water problems.

(15) Dils, R. E.
1952. Changes in some vegetation, surface soil and surface runoff characteristics of a watershed brought about by forest cutting and subsequent mountain farming. Ph. D. Thesis, Mich. State Coll. Agric. & Appl. Sci., 205 pp.

Conversion of a 23-acre forested watershed at the Coweeta Hydrologic Laboratory to a mountain farm resulted in changes in vegetation, physical properties of soils, and runoff. Marked and variable differences in infiltration rates, permeability, percentage of water-stable aggregates, organic matter content, volume weight, and pore size distribution of soils were observed in portions of the watershed treated in different ways. Yearly soil losses increased from about 154 pounds per acre under forest cover to well over 1 ton per acre under mountain farming. Storm peaks increased sharply, and volumes of stormflow increased somewhat. Practical implications for land use are discussed.

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1953. Influence of forest cutting and mountain farming on some vegetation, surface soil and surface runoff characteristics. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 24, 55 pp.

Infiltration rates, organic matter content, density, and porosity of soils were all adversely affected by conversion of a forested watershed at Coweeta to a mountain farm. Storm runoff volumes, peak discharge rates, flood peak frequencies, and overland flow were all increased. Mountain farming shortly proved to be uneconomical.

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1957. A guide to the Coweeta Hydrologic Laboratory. USDA Forest Serv. Southeast. Forest Exp. Stn., 40 pp.

This report replaces the 1948 guidebook (Item 181) and summarizes the contributions of many researchers who have worked at Coweeta. The area and its water resources are described, and research methods and results are outlined.

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1960. Soil moisture distribution between trees in a thinned loblolly pine plantation. J. For. 58: 221-222.

Variation in soil moisture is shown to be related to tree location, and associated sampling problems created by unequal moisture distribution in pine plantations are discussed.

(19) ______
1962. A method for determining the slope of neutron moisture meter calibration curves. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 154, 6 pp.

A new water-addition method is presented which allows a check of slope coefficients derived from gravimetric calibrations of neutron moisture probes. Coefficients obtained by the new method differed from those obtained by gravimetric calibration by as much as 36 percent. Differences were attributed to bias arising because drying temperatures used in gravimetric calibration failed to remove all bound water and because the gravimetric method failed to account for differences in neutron absorption between soils.

*(20) ______
1962. Variance of nuclear moisture measurements. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 143, 11 pp.

Several conclusions can be drawn concerning the use of nuclear equipment to measure moisture in Piedmont soils: (1) The error in measuring moisture content is particularly large in soils with varying texture. (2) Analysis of moisture losses, which utilizes covariance techniques to remove the textural effect, is more precise for detecting moisture differences than for determining total moisture content. (3) The error in moisture measurements increases as the range of clay content increases.

*(21) ______
1966. Effects of species and arrangement of forests on evapotranspiration. Natl. Sci. Found. Adv. Sci. Semin., Int. Symp. Forest Hydrol. Proc. 1965: 451-461.

This paper reviews research concerned with the effects of plant species and arrangement on evapotranspiration. In general, grasses use less water than forest species because of the shallower rooting habits of grass; usually, differences in evapotranspiration which occur between forest species could not be detected except where rooting depths were unequal. Evapotranspiration varies with stand density and vegetative height, at least in humid regions, and evapotranspiration probably varies with slope and aspect as well.

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The first 30 years of research at the Coweeta Hydrologic Laboratory and plans for future research are discussed.

*(23) Douglass, J. E.
1966. Volumetric calibration of neutron moisture probes. Soil Sci. Soc. Am. Proc. 30: 541-544.

A volumetric method of estimating the slope (b coefficient) of the calibration curve for a neutron moisture probe is presented. Coefficients obtained for three probes did not differ significantly between soil series or between horizons within a series. Simply dividing the count rate in water by 100 gave a value virtually identical to the b coefficient determined volumetrically for these probes and soils. Agreement was excellent between measured outflow and outflow predicted from neutron measurements made with a volumetrically calibrated probe.

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1967. Man, water, and the forest. Forest Farmer 26(5): 6-7, 18, 20.

The interrelationships between man's activities, water, and the forest are discussed.

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1969. Low herbicide concentration found in streamflow after a grass cover is killed. Southeast. Forest Exp. Stn., U.S.D.A. Forest Serv. Res. Note SE-108, 3 pp.

Grass cover on an Appalachian watershed was sprayed with atrazine and paraquat and later with atrazine and 2,4-D. Although grass growing in the stream channel was sprayed, atrazine and paraquat levels in water samples were low. During a second application, a lo-foot strip on either side of the channel was left unsprayed; no increase in atrazine and no trace of 2,4-D were detected in streamflow.

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1947. Research in the Central Piedmont. Forest Farmer 6(12): 4, 8.

The establishment of Calhoun Experimental Forest in the Central Piedmont of South Carolina is discussed, and problems resulting from the abused agricultural land as well as the research approach to be followed in rehabilitating the soils are described.

(27) ________ and Fletcher, P. W.
1947. Effect of removal of stream-bank vegetation upon water yield. Am. Geophys. Union Trans. 28: 105-110.

This is a preliminary report on the results of removing stream-bank vegetation from Watershed 6 at the Coweeta Hydrologic Laboratory. Diurnal fluctuations in the streamflow were virtually eliminated. Cutting of riparian growth also resulted in an increase in yield of sufficient magnitude to be significant in water resource management.

(28) Fletcher, P. W.
1949. Better land resource management is coming to the Missouri Ozarks. Univ. MO. For. Club, MO. Log 1949, II: 32-35.

A forester describes the improvements which occurred in the forested and agricultural landscape during 11 years of enlightened management.

(29) Freeland, F. D., Jr.
1956. The effects of a complete cutting of forest vegetation and subsequent annual cutting of regrowth upon some pedologic and hydrologic characteristics of a watershed in the southern Appalachians. Ph. D. Thesis, Mich. State Univ. Agric. & Appl. Sci., 182 pp.

Vegetation on one of two calibrated watersheds at Coweeta was cut in 1941, slash was lopped, but no products were removed; thereafter, annual regrowth was cut (except from Sept. 1942 until Feb. 1946). Although soils on the two areas were uniform initially, field and laboratory analyses in 1953 showed a lower percentage of large, water-stable aggregates in the surface soil layers of the treated watershed, as well as a lower water stability of these aggregates. Unincorporated humus on the soil was less on the treated watershed, and the rate of decomposition of humus was accelerating. Dry clods, volume weight and porosity, permeability and field capacity, moisture equivalent, and moisture contents during the growing season were not significantly changed by treatment, but air and soil temperatures were increased. Water yield from 1941 through 1953 on the treated watershed averaged 10 inches higher than was predicted for the uncut watershed. Low flows were increased almost 100 percent, and peak flows were only slightly increased.

(30) Greene, G. E.
1950. Land use and trout streams. J. Soil & Water Conserv. 5: 125-126.

Maximum stream temperatures rose appreciably when a forested watershed at Coweeta was converted to a mountain farm. Because absence of shade can increase stream temperatures, riparian vegetation should be carefully manipulated to maintain optimum temperatures for growth and development of trout and aquatic organisms.

(31) ________
1953. Soil temperatures in the South Carolina Piedmont. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 29, 16 pp.

Data are presented on temperatures at eight depths in the upper 6 feet of soil under a shortleaf pine-hardwood stand, a loblolly pine plantation, broomsedge grass field, and a barren site. Vegetative cover had greatest effect in the summer, and subsurface temperatures decreased as vegetative cover increased. Minimum temperatures at 6 feet varied from 50° to 52° F. regardless of cover.

(32) Grzenda, A. R., Nicholson, H. P., Teasley, J. I., and Patric, J. H.
1964. DDT residues in mountain stream water as influenced by treatment practices. J. Econ. Entomol. 57: 615-618.

DDT residues in Coweeta streams after spraying for elm spanworm by airplane in 1961 and by helicopter in 1962 are compared. DDT contamination of Coweeta Creek was negligible after precise application by helicopter in upslope and ridge areas.

(33) Hassler, W. W., and Tebo, L. B., Jr.
1958. Fish management investigations on trout streams. N. C. Wildl. Resour., Fish Div., Proj. Completion Rep. Proj. F-4-R, 118 pp.

This is a report of the cooperative Dingell-Johnson investigation at Coweeta Hydrologic Laboratory. The report includes an extensive description of bottom fauna and describes the effects of erosion debris and riparian cuttings upon fish life.

*(34) Helvey, J. D.
1964. Rainfall interception by hardwood forest litter in the southern Appalachians. Southeast. Forest Exp. Stn., U. S. Forest Serv. Res. Pap, SE-8, 9 pp.

Moisture interception by hardwood litter was measured during 1961 and 1962. The maximum field water content--water retained against drainage--averaged 215 percent of ovendry weight. About 1 inch of throughfall was required to wet the litter to this maximum. The amount of water evaporated per month from litter was greater during the dormant season. Interception loss during 1962 was about 2.2 inches and the long-term average is estimated to be about 3 inches.

*(35) ________
1967. Interception by eastern white pine. Water Resour. Res. 3: 723-729.

Measurements taken in a 10-, a 35-, and a 60-year-old stand of eastern white pine in the southern Appalachians of western North Carolina were used to derive regression equations for estimating throughfall, stemflow, and the sum of throughfall and stemflow from measurements of gross rainfall. Equations for total interception loss were derived and used to predict total seasonal interception loss (I) from measurements of total seasonal rainfall (ΣP) and number of storms (N). For the lo-year-old stand, $I = 0.05(N) + 0.08(\Sigma P)$; for the 35-year-old stand, $I = 0.05(N) + 0.12(\Sigma P)$; and for the 60-year-old stand, $I = 0.06(N) + 0.18(\Sigma P)$. Total interception loss in white pine increased with stand age, and total loss from all pine stands studied exceeded losses calculated for mature hardwoods.

(36) ________
1968. Reply to Editor Langbein in answer to Professor Miller's comments on "Interception by eastern white pine." Water Resour. Res. 4: 455-456.

This is a rebuttal to comments by Professor Miller on the article "Interception by Eastern White Pine."

(37) ________ (contrib.)
1970. Interception of rain, pp. 89-93. In Representative and experimental basins. An international guide for research and practice, Vol. 4. UNESCO. Haarlem: Henkes-Holland.

Some guidelines are presented for designing studies of rainfall interception in forest vegetation. Methods are presented for sampling gross rainfall, throughfall, stemflow, and litter interception loss. The necessary information is presented for determining a first approximation of the sampling intensity needed to achieve a desired level of accuracy.

*(38) Helvey, J. D., and Hewlett, J. D.
1962. The annual range of soil moisture under high rainfall in the Southern Appalachians. J. For. 60: 485-486.

Observations of soil moisture at Coweeta suggest that forest vegetation at this Laboratory rarely, if ever, suffers true drought. Seasonal changes in soil moisture were strongly correlated with changes in streamflow.

(39) ________ and Patric, J. H.
1965. Canopy and litter interception of rainfall by hardwoods of eastern United States. Water Resour. Res. 1: 193-206.

Results from all available studies of rainfall interception by hardwoods of the eastern United States vary over a small range. Data from past studies were used to develop regression equations describing the relation between gross rainfall, throughfall, and stemflow for eastern hardwood forests during the growing and dormant seasons.

*(40) ________ and Patric, J. H.
1966. Design criteria for interception studies. Symp. Des. Hydrol. Networks. Int. Assoc. Sci. Hydrol. Bull. 67: 131-137.

This report, gleaned from over 50 studies, defines variability of interception parameters and provides sampling designs for obtaining estimates to selected levels of probability for each parameter mean. A new method for estimating stemflow is outlined which greatly reduces variability inherent in the traditional single-tree method. These sampling and analytical methods will help insure that results of different studies are comparable.

(41) Hertzler, R. A.
1938. Determination of a formula for the 120° V-notch weir. Civ. Eng. 8: 756-757.

Design of a 120° V-notch sharp-crested weir for accurate measurement of flows up to 26 second-feet is described. For a 2-foot head, the 120° notch has 1.73 times the capacity of a 90" notch and slightly greater capacity than the 2.6-foot rectangular weir. Weir blades were constructed of $3\frac{1}{2}$- by $3\frac{1}{2}$-inch structural angle iron. The discharge formula was $Q = 4.43\ H^{2.449}$, where Q = discharge in second-feet and H = observed head on weir.

(42) ________
1939. Engineering aspects of the influence of forests on mountain streams. Civ. Eng. 9: 487-489.

This article discusses the objectives of the hydrologic research program at Coweeta, Bent Creek and Copper Basin, the weir instrumentation used, and typical early analyses and applications. The application of Horton's infiltration theory to forest lands which have high infiltration rates is questioned. Unit graph analyses of runoff showed that peak percentages of runoff were inversely related to basin area, basal lengths of the distribution graphs were directly related to drainage area, and that the effects of vegetative cover were reflected in both peak percentages and width of the distribution graphs. A quantitative ranking of peak discharge from four cover types is presented.

*(43) Hewlett, J. D.
1957. Coweeta Hydrologic Laboratory. USDA Forest Serv. Southeast. Forest Exp. Stn., 8 pp.

This booklet describes research conducted at Coweeta to develop practical methods of managing forest land for maximum timber production while providing for flood control and maintaining the quality and quantity of water needed for industrial, municipal, and agricultural uses. Results of watershed clearings, mountain farming, woodland grazing, and proper logging procedures are illustrated.

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1958. Pine and hardwood forest yield. J. Soil & Water Conserv. 13: 106-109.

This paper discusses the theoretical concepts and experimental results which indicate that conifers use more water than hardwoods. Two catchment studies of the effect on water yield of converting hardwoods to white pine are described.

(45) ______
1961. Response of fescue to natural moisture gradient on an artificial slope, USDA Forest Serv. Southeast. Forest Exp. Stn. Res. Notes 152, 2 pp.

Minor changes in soil moisture stress on well-watered natural slopes may, in part, account for observed reductions in form and vigor of plants with increasing elevation.

*(46) ______
1961. Soil moisture as a source of base flow from steep mountain watersheds. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 132, 11 pp.

Model studies of unsaturated flow in sloping soil columns show that unsaturated flow of water is an important source of base flow in mountain streams.

(47) ______
1962. Internal water balance of forest trees on the Coweeta watershed. Ph.D. Thesis, Duke Univ., 122 pp.

Measurement of the internal water balance of Cornus florida L., Quercus prinus L., Nyssa sylvatica Marsh., and Oxydendrum arboreum DC. throughout a summer revealed that soil and atmospheric moisture stress were related to variation in leaf-water deficit (WD) as calculated by Stocker's formula. WD was determined on whole leaves and compared to a well-known disk technique. Definite response of WD to soil moisture stress between 0.3 and 2.0 atmospheres was produced within the plots; responsiveness of species decreased in the order listed above. WD was shown to depend jointly on soil and atmospheric moisture stress; C. florida was particularly responsive to both factors.

(48) ______
1964. Letter to editor on article "Groundwater: Definition" by H. E. Thomas and L. B. Leopold. Science 144(3625): 1407-1408.

This letter questions the definition of groundwater used in the article.

*(49) Hewlett, J. D,
1964. Research in hydrology of forested headwaters of the Coweeta Hydrologic Laboratory. Twenty-Ninth North Am. Wildl. & Nat. Resour. Conf. Trans. 1964: 103-112.

The author provides background and review of research in forest hydrology at Coweeta and plans for future staffing and research at the Laboratory.

(50) ________
1964. Water or forest - can we have all we need of both ? Front. Plant Sci. 17: 2-3.

The author outlines a recent experiment with a transpiration inhibitor and cites benefits possible if this or related tests succeed.

(51) ________ and Douglass, J. E.
1961. A method for calculating error of soil moisture volumes in gravimetric sampling. Forest Sci. 7: 265-272.

A method for calculating error of soil moisture volumes in gravimetric sampling is presented. Limitations in sampling soil density and percentage of moisture to determine inches of water render the gravimetric method a poor tool for hydrologic research.

*(52) ________ and Douglass, J. E.
1968. Blending forest uses. Southeast. Forest Exp. Stn., U.S.D.A. Forest Serv. Res. Pap. SE-37, 15 pp.

Compatibility of forest management practices on a 360-acre southern Appalachian watershed, along with conflicts among uses, is examined in this unique experiment to determine the feasibility of intensive management for wood, water, wildlife, and recreation. An efficient and stable access system is stressed, and the effect of various woods practices on the four basic resources is rated. Increases are shown in water yield, game forage, quality timber growth, and general use of the area, and some unresolved conflicts among uses of the forest are revealed.

(53) ________ Douglass, J. E., and Clutter, J. L.
1964. Instrumental and soil moisture variance using the neutron-scattering method. Soil Sci. 97: 19-24.

The variance in estimates of soil moisture as determined by the neutron-scattering method is examined and related to field data from two research areas. Instrument and timing errors are shown to contribute insignificantly to the standard error of estimate. Furthermore, their contribution to estimates of moisture change with time is negligible as long as the timing interval used at each observation exceeds 30 seconds.

*(54) Hewlett, J. D., and Helvey, J. D.
1970. Effects of forest clear-felling on the storm hydrograph. Water Resour. Res. 6: 768-782.

A statistical analysis of all major storm hydrographs before and after clear-felling a mature hardwood forest on a 108-acre calibrated catchment revealed that, after felling, stormflow volume was significantly (0.001 level) increased 11 percent overall, or 0.23 inch at the mean stormflow volume of 2.1 inches. Peak discharge increased slightly after felling (about 6 c. f. s. m. or 7 percent at the mean peak flow of 92 c. f. s. m.). Time to peak, recession time, and duration of stormflow were tested to an accuracy within 10 percent of their respective mean values (0.05 level), but no treatment effect was detected. Increases in stormflow as a result of felling ranged from 0 in small floods to 1.9 inches during a record 7-day flood sequence.

*(55) ________ and Hibbert, A. R.
1961. Increases in water yield after several types of forest cutting. Int. Assoc. Sci. Hydrol. Bull. 6(3): 5-17.

Effects of timber and brush removal on water yields from small watersheds are examined in the light of 25 years of hydrologic research at Coweeta.

*(56) ________ and Hibbert, A. R.
1963. Moisture and energy conditions within a sloping soil mass during drainage. J. Geophys. Res. 68: 1081-1087.

A model of a sloping soil profile is used to show that slow, unsaturated flow of soil moisture above the water table furnishes much of the sustained streamflow between storms in mountain land.

*(57) ________ and Hibbert, A. R.
1966. Factors affecting the response of small watersheds to precipitation in humid areas. Natl. Sci. Found. Adv. Sci. Semin., Int. Symp. Forest Hydrol. Proc. 1965: 275-290.

A numerical rating system, the response factor, was developed from precipitation and streamflow records for use in classifying the hydrologic response of small watersheds in humid areas. Long-term hydrograph records from 15 forested watersheds in the eastern United States were separated into quick and delayed flow by computer and ranked according to mean precipitation, quick flow, and the response factors quick flow /precipitation and quick flow/ total water yield.

(58) ________ and Kramer, P. J.
1963. The measurement of water deficits in broadleaf plants. Protoplasma 57: 381-391.

A comparison of the disk technique with Stocker's whole leaf method for determining water deficit of some hardwood trees reveals confusion in existing terms and methods. The water relations of leaf disks cut from broadleaf trees cannot be assumed to be the same as whole leaves, because more water per unit weight is usually required to saturate excised disks. Stocker's term wasser defizit (WD) and the whole leaf method, when modified to allow shorter equilibration schedules, remain the best way to express and measure water deficits in forest trees.

(59) Hewlett, J. D., and Metz, L. J.
1960. Watershed management research in the Southeast. J. For. 58: 269-271.

This article is a review of research on watershed management at the Coweeta Hydrologic Laboratory and Union Research Center.

(60) ________ and Patric, J. H.
1963. An example of multiple use on a small mountain watershed. 7th Annu. Meet. Ga. Chapter Soil Conserv. Soc. Am. Proc. 3: 12-26.

An example of multiple use on a 356-acre watershed at Coweeta Hydrologic Laboratory is presented. This report discusses the concept of forest access as being the key to management. Plans for management of the area for water, timber, wildlife, and recreational values are presented.

(61) ________ and Patric, J. H.
1963. A pilot test of multiple use on a small mountain watershed. 42nd Annu. Meet. Appalachian Sect. Soc. Am. For. Proc., pp. 11-18.

A pilot test of the multiple-use concept on a 356-acre watershed at Coweeta Hydrologic Laboratory is presented. This report discusses that concept in terms of management of the area for water, timber, wildlife, and recreational values. A proper access system is cited as the key to effective resource management.

(62) Hibbert, A. R.
1961. A study of commonly used hydrologic concepts and their application in runoff analysis on small mountain watersheds. M. S. Thesis, Utah State Univ., 80 pp.

Analysis of hydrograph records from six small mountain watersheds at Coweeta indicated that lag time is apparently the most meaningful of the time elements of runoff. The unit hydrograph method of runoff prediction proved adequate for channel precipitation but gave poor results when applied to overland flow. No concept or method of runoff analysis was found which would adequately describe or predict behavior of subsurface stormflow.

*(63) ________
1966. Forest treatment effects on water yield. Natl. Sci. Found. Adv. Sci. Semin., Int. Symp. Forest Hydrol. Proc. 1965: 527-543.

Results are reported for 39 studies of the effect of altering forest cover on water yield. Taken collectively, these studies reveal that forest reduction increases water yield and that reforestation decreases water yield.

*(64) Hibbert, A. R.
1969. Water yield changes after converting a forested catchment to grass. Water Resour. Res. 5: 634-640.

After a forested catchment was converted to grass, the amount of evapotranspiration was closely related to the amount of grass produced. During years when grass production was high, water yield from the catchment was about the same as or less than the expected yield from the original forest. As grass productivity declined, water yield gradually increased until it exceeded the predicted yield from the forest by over 5 inches annually. The grass appeared to evaporate more water early in the spring and less water late in the summer than the original forest cover.

(65) ________ and Cunningham, G. B.
1966. Streamflow data processing opportunities and application. Natl. Sci. Found. Adv. Sci. Semin., Int. Symp. Forest Hydrol. Proc. 1965: 725-736.

The techniques used at the Coweeta Hydrologic Laboratory for processing streamflow records from recorder charts and analog-to-digital recorder tape to final integration of discharge are discussed in detail.

(66) Hilmon, J. B., and Douglass, J. E.
1968. Potential impact of forest fertilization on range, wildlife, and watershed management, pp. 197-202. In Forest fertilization theory and practice symposium 19%. Tenn. Val. Auth., Muscle Shoals, Ala.

This paper reviews current information concerning the impacts of forest fertilization on forage, wildlife, and water resources.

(67) Hoover, M. D.
1944. Effect of removal of forest vegetation upon water yields. Am. Geophys. Union Trans., Part VI: 969-977.

A clearcutting experiment on Coweeta Watershed 17 is described, and effects of the cutting and subsequent treatment on increasing water yield are presented. Peak discharges were not significantly increased by the cutting, and surface runoff did not occur after treatment. Data indicate that a forest stand annually transpires 17 to 22 inches of water.

(68) ________
1945. Careless skidding reduces benefits of forest cover for watershed protection. J. For. 43: 765-766.

Careless skidding creates channels which concentrate runoff from road surfaces and cause erosion which is unnecessary if roads are carefully located and constructed. Techniques which minimize erosion from skid roads are presented.

(69) ________
1950. Hydrologic characteristics of South Carolina Piedmont forest soils. Soil Sci. Soc. Am. Proc. 14: 353-358.

In this study, capillary and noncapillary pore space and retention and detention storage in a badly depleted Vance soil and in a forest soil were compared. The hydrologic significance of the differences between soils and the need for restoration are discussed.

(70) Hoover, M. D.
1952. Influence of plant cover on soil moisture in the Piedmont. (Abstr.) Assoc. South. Agric. Work. Proc. 49: 172.

Data are presented which show the relationship between vegetative cover and surface runoff in the South Carolina Piedmont.

(71) ________
1952. Water and timber management. J. Soil & Water Conserv. 7: 75-78.

As demand for water increases, management of forested headwaters assumes greater importance. Compatibility of objectives in the management of timber and water is demonstrated, and management practices which protect the values of each resource are stressed.

*(72) ________
1953. Interception of rainfall in a young loblolly pine plantation. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 21, 13 pp.

The following regression equations were developed from measurements of interception loss in a lo-year-old plantation of loblolly pine in the South Carolina Piedmont: Throughfall = 0.732 (rain in open) - 0.016; stemflow = 0.222 (rain in open) - 0.018; and net rainfall to forest floor = 0.954 (rain in open) - 0.034.

(73) ________ and Hursh, C. R.
1943. Influence of topography and soil depth on runoff from forest land. Am. Geophys. Union Trans., Part II: 693-698.

Data are presented on rainfall and discharge for seven watersheds at Coweeta during a storm on December 27-29, 1942. The difference in peak discharges is assigned in part to higher rainfall at higher elevations, but peaks were also related to soil depth, topography, and hydrologic characteristics associated with different elevations.

(74) ________ and Hursh, C. R.
1943. Installation of shallow observation wells. USDA Forest Serv. Appalachian Forest Exp. Stn. Tech. Note 56, 5 pp.

The location, installation, and operation of shallow ground-water observation wells are described. This Note is of value to field personnel involved in well installation and in the analysis of observations taken from wells constructed by the methods described.

(75) ________ and Lunt, H. A.
1952. A key for the classification of forest humus types. Soil Sci. Soc. Am. Proc. 16: 368-370.

A key is presented for classifying major organic layers into Mull, Duff Mull, and Mor. It is applicable for well- and moderately well-drained soils. Basic criteria in the classification are (1) presence or absence of an H layer; (2) the degree of incorporation of organic matter into the upper mineral soil; and (3) the structure, thickness, and organic content of the H layer and the A horizon.

(76) Hoover, M. D., Olson, D. F., Jr., and Greene, G. E.
1953. Soil moisture under a young loblolly pine plantation. Soil Sci. Soc. Am. Proc. 17: 147-150.

The moisture regimen (as determined by the resistance method) of the soil at depths of 0 to 15, 15 to 30, 30 to 42, 42 to 54, and 54 to 66 inches beneath a 12-year-old loblolly pine plantation in the South Carolina Piedmont is described. During the growing season, moisture was lost from throughout the upper 5½ feet of soil. Water was withdrawn most rapidly from the zone where it was most readily available, regardless of depth.

*(77) ________ Olson, D. F., Jr., and Metz, L. J.
1954. Soil sampling for pore space and percolation. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 42, 28 pp.

This report summarizes and describes equipment which has been developed to collect soil cores and methods for measurement of pore space and percolation rates.

(78) Hursh, C. R.
1928. Litter keeps forest soil productive. South. Lumberman 133(1734): 219-221.

Forest soils are, for the most part, self-fertilized by organic material derived from litter. Litter has a beneficial effect on the ability of soil to absorb and retain moisture, on chemical characteristics, and on biological activity. The effects of fire and aspect on litter production are discussed.

(79) ________
1931. Abandoned mountain farms an erosion menace but a forestry opportunity. Farmers Fed. News 11(12): 3, 5.

The author describes agricultural practices which leave mountain soils exposed to erosion and recommends that slopes unsuitable for agriculture not be cleared and that abandoned land be converted to pasture or forest cover to prevent erosion.

(80) ________
1935. Control of exposed soil on road banks. USDA Forest Serv. Appalachian Forest Exp. Stn. Tech. Note 12, 4 pp.

Increased erosion, siltation, and road maintenance can be largely eliminated by covering road banks with litter or revegetating banks at the time of road construction. The simplest and most practical measures include planting, seeding, and use of stake and brush wattles. Selection of suitable plant species is discussed.

(81) ________
1937. Frog makes record. USDA Forest Serv. Bull. 21(16): 6.

The recording of the journeys of a small frog on the float of a water-level recording instrument in a ground-water observation well is described.

(82) Hursh, C. R.
1937. Runoff measurements from eroded land. Tenn. Val. Sect. Am. Soc. Civ. Eng. 1937: 12 pp.

Frequency distributions of peak discharge, rainfall intensity, and stormflow volume as a percentage of rainfall are presented for three experimental locations in the Blue Ridge Mountains. Frequency distributions compared were for denuded land, overgrazed pasture, abandoned farmland, and forested catchments. Prevention and control of runoff are discussed in this early, definitive work on runoff from small watersheds.

(83) ________
1938. Mulching for road bank fixation. USDA Forest Serv. Appalachian Forest Exp. Stn. Tech. Note 31, 4 pp.

Road bank fixation on dry, infertile sites is particularly troublesome, and the use of mulches on dry and infertile banks at the time banks are planted is the most successful and inexpensive method of stabilization. Transplanting of woody shrubs offers no particular problem. Two general methods of mulch application are (1) staked weed mulches and (2) staked brush and litter mulches. The author lists materials, equipment, labor requirements, and procedures for mulch application.

(84) ________
1939. Roadbank stabilization at low cost. USDA Forest Serv. Appalachian Forest Exp. Stn. Tech. Note 38, 20 pp.

Low-cost methods of establishing vegetation on cut-and-fill slopes of roadbanks are described. Planting and seeding without preliminary stabilization are too expensive for extensive use. Two types of mulch application--staked weed mulches and staked brush and litter mulches--are outlined. Requirements for labor and equipment are listed, and procedures for mulch application are discussed.

(85) ________
1940. Outline for compiling precipitation and runoff data from small drainage areas. USDA Forest Serv. Appalachian Forest Exp. Stn. Tech. Note 34, 59 pp.

This is the original description of procedures used by the Station for the systematic compilation of continuous records of precipitation and stream discharges.

(86) ________
1941. The geomorphic aspects of mudflows as a type of accelerated erosion in the Southern Appalachians. Am. Geophys. Union Trans., Part II: 253-254.

Under certain conditions, high infiltration rates and deep soils give rise to conditions which cause mudflows. After prolonged rainfall, the soil mass is surcharged with water; a major surface break, such as uprooting of large trees, may start mass movement. The nature of movement of the soil mass depends on the slope of the contact zone with stable material.

(87) Hursh, C. R.
1942. The naturalization of roadbanks. Roads & Bridges (Can.) 80(7): 22-26, 131-137.

Naturalization and stabilization of roadbanks by vegetation are discussed as part of road construction. Experiments' begun in 1934 at the Appalachian Forest Experiment Station indicate that seeding, planting, fertilizing, and mulching are methods of stabilizing banks.

(88) ______
1942. The naturalization of roadbanks. USDA Forest Serv. Appalachian Forest Exp. Stn. Tech. Note 51, 36 pp.

The problems involved in natural stabilization of roadbanks, including the factors limiting plant growth and the origin and causes of soil stability, are discussed. Suggestions are given for stabilization of banks with different slopes and with moist, fertile soil and dry, infertile soil. Establishment of vegetation with commercial fertilizers, seeding, planting, and mulches is discussed.

(89) ______
1943. Discussion of paper entitled "Determination of the effects of watershed-management on mountain streams" by C. L. Wicht. Am. Geophys. Union Trans. 1943: 606-608.

Elimination of the effects of climatic variability and factors such as size, shape, and soil-depth of watersheds through various statistical methods is questioned. Statistical methods are recognized as valuable research tools, but in order to develop practical watershed management techniques, the very factors to be eliminated in the experimental design must be evaluated. The concept of watershed standardization over a period of years is discussed as a procedure which eliminates comparison of the physical characteristics of one watershed with those of another.

(90) ______
1944. Appendix B--report of sub-committee on subsurface-flow. Am. Geophys. Union Trans., Part V: 743-746.

Literature on subsurface flow is reviewed, and the lack of records from suitable experimental watersheds is cited as a handicap in interpreting the nature of subsurface stormflow.

(91) ______
1944. Water storage limitations in forest soil profiles. Soil Sci. Soc. Am. Proc. 8: 412-414.

At Coweeta, measurements of macro-pore space were used to estimate differences in water storage between natural forest soil and soil from pine stands on eroded old-field land.

(92) Hursh, C. R.
1945. Plants, shrubs, trees in slope stabilization. Contract. & Eng. Mon. 42(6): 26-27.

Natural vegetation is the most efficient and esthetically pleasing means of roadbank stabilization. Deep-rooted legumes such as perennial lespedeza and Scotch broom together with native woody shrubs are advised. In the Eastern States, rainfall and site conditions favor a plant succession toward a forest cover, but the possibility of trees being uprooted or interfering with viewing distance should be taken into account.

*(93) ______
1946. The eastern forester and his watersheds. J. For. 44: 1037-1040.

The author pointedly questions whether the average forester is trained to manage water resources of the forest. Basic concepts of geophysical science (soils, climatology, and the origin and distribution of water on the earth's surface) are discussed in relation to the water resource and its management.

(94) ______
1946. Water resources of South Carolina. (Abstr.) Chemurg. Pap. 1946 Ser. 4: 473-473.3.

The author discusses the existing water resources of South Carolina as these have been modified by past land-use. Future enhancement of water resources will depend on public interest and intelligent cooperation of landowners.

(95) ______
1946. Watershed management - 1931--1946. USDA Forest Serv. Southeast. Forest Exp. Stn. Anniv. Rep. 1921-1946: 43-50.

This is a progress report of the activities at Coweeta Hydrologic Laboratory and Copper Basin from 1931 to 1946.

(96) ______
1946. . Where little waters write big stories. Am. Forests 52: 574-577, 603.

The author describes watershed experiments underway at the Coweeta Hydrologic Laboratory and discusses what has been learned about water yield and erosion from studies of complete removal of forests, of clearing and cultivating steep forest lands, and of woodland grazing.

(97) ______
1947. Water resource management. N.C. Eng. 3(2): 9-12, 40.

This article is a general summary on the research facilities, program, and findings at the Coweeta Hydrologic Laboratory.

(98) ______
1947. Watershed experiments conducted in giant outdoor laboratory. Timber Top, 10(4): 2-4, 9.

The author reviews the objective of watershed research at the Coweeta Hydrologic Laboratory and discusses the effects on water yield of clearing and cultivating steep forest lands, of complete removal of forest trees, of woodland grazing, and of logging and burning watersheds.

(99) Hursh, C. R.
1948. Local climate in the Copper Basin of Tennessee as modified by the removal of vegetation, U. S. Dep. Agric. Circ. 774, 38 pp.

Meteorological records were collected from three contiguous land areas that once supported a uniform hardwood forest but are now characterized by three distinct vegetative conditions: forest, grass, and bare soil. Differences in air and soil temperatures, wind, evaporation, moisture saturation deficit of the air, and rainfall indicate that each vegetative zone possesses a distinctive local climate.

(100) ________
1949. Climatic factors controlling roadside design and development. Highw. Res. Board, Natl. Res. Counc. Mag., pp. 9-19.

Factors which influence the revegetation of roadbanks--drying by wind, soil temperatures, frost action, mulching, and road design--are discussed.

(101) ________
1951. Research in forest-streamflow relations. Unasylva 5: 2-9.

The objectives of the research program at the Coweeta Hydrologic Laboratory are defined, and current watershed studies are described. The practical significance of research findings in the management of watershed resources is discussed.

(102) ________
1951. Watershed aspects of the New York water supply problems. J. For. 49: 442-444.

Watershed aspects of New York's problems with water supply from the Croton and Catskill systems are discussed. Past practices in forest conservation have contributed to the development and protection of these systems. However, complete closure is not synonymous with watershed management; vegetative management is often a direct means of improving soil and increasing water resource values. Watershed problems which merit further consideration are listed by priority.

(103) ________
1952. Forest management in East Africa in relation to local climate, water and soil resources. East Afr. Agric. Organ. Annu. Rep. 1952: 26-35.

As a Fulbright Research Scholar, the author presents his views on East Africa's need for expansion of farm forestry, improvement of damaged local climate, management of grazed areas, and catchment management and research.

(104) ________
1952. Now is the time. Farmers Fed. News 32(7): 12.

Owners of idle land are urged to initiate conservation measures. The value of trees for protection against erosion, stream sedimentation, and local floods is emphasized.

(105) Hursh, C. R.
1952. Water from the family spring. Living Wilderness 16(39): 11-12.

The part a spring plays in rural family life is described.

(106) ________ and Barrett, L. I.
1931. Forests of Georgia highlands, their importance for watershed protection, recreation and wood production. Ga. Forest Serv. Bull. 15, 32 pp.

The results of an early investigation of the value of Georgia's mountain forests with respect to timber production, watershed protection, and recreation use are presented.

(107) ________ and Brater, E. F.
1941. Separating storm-hydrographs from small drainage-areas into surface- and subsurface-flow. Am. Geophys. Union Trans., Part III: 863-871.

This classic study of hydrographs from streams and ground-water wells demonstrates that hydrographs from forested catchments at Coweeta are comprised of channel precipitation and various subsurface flow components rather than overland flow. In accounting for the stormflow volume, the authors describe five sources of stormwater. They also describe the process which became known 20 years later as the concept of variable source area.

(108) ________ and Connaughton, C. A.
1938. Effects of forests upon local climate. J. For. 36: 864-866.

Early studies of the effects of forests on climate as authorized in the United States under the McSweeney-McNary Forest Research Act of 1928 are described. Indications are that forests exert little influence on climate of large areas but have a marked effect on local or environmental climate. Observations were made at Copper Basin, a 7,000-acre area completely denuded by smelter fumes, and in the adjacent hardwood forest. The information obtained on microclimate has application in studies of fire, shelter-belts, forest management, and watershed management.

(109) ________ and Craddock, G. W.
1949. Review on book "Hydrology" by C. 0. Wisler and E. F. Brater. J. For. 47: 844-845.

As the citation indicates.

(110) ________ and Crafton, W. M.
1935. Plant indicators of soil conditions on recently abandoned fields. USDA Forest Serv. Appalachian Forest Exp. Stn. Tech. Note 17, 3 pp.

Growing conditions on abandoned farm fields to be reforested are indicated by the species of plants present. Plant indicators which serve as guides in the selection of tree species and planting methods are given for four grades of sites, as determined by the amounts of soil moisture and nutrients present. Plant succession on each of these sites is discussed.

(111) Hursh, C. R., and Fletcher, P. W.
1943. The soil profile as a natural reservoir. Soil Sci. Soc. Am. Proc. 7: 480-486.

A 7-acre watershed was intensively instrumented with ground-water wells to test the concept that the soil profile has a measurable storage capacity and a regulating effect on ground-water discharge. Well elevations were correlated with measured discharge so that aquifer dimensions and porosity required for detention storage could be estimated. Three types of reservoir functions of the soil profile were recognized.

(112) ________ and Haasis, F. W.
1931. Effects of 1925 summer drought on Southern Appalachian hardwoods. Ecology 12: 380-386.

Total rainfall recorded at Asheville, North Carolina, from May to August 1925 was 5.11 inches, whereas the normal is 15.97 inches. Trees on ridges and upper slopes between 2,100 and 2,600 feet elevation became wholly or partially brown during August and September, and some species (chiefly oaks and shortleaf and pitch pines) experienced premature leaf fall. Leaf browning and early fall were more pronounced on younger trees and were particularly severe on dogwood, sourwood, and chestnut. Chestnut oaks and pine survived on areas where black oaks were completely killed.

(113) ________ and Hoover, M. D.
1942. Naturalized roadbanks. Better Roads 12(6): 13-15, 24-25; 12(7): 17-20.

Naturalization and stabilization of roadbanks by vegetation are discussed as part of road construction. Experiments begun in 1934 at the Appalachian Forest Experiment Station indicate that seeding, planting, fertilizing, and mulching are practical methods of stabilizing banks.

(114) ________ and Hoover, M. D.
1942. Soil profile characteristics pertinent to hydrologic studies in the southern Appalachians. Soil Sci. Soc. Am. Proc. 6: 414-422.

The two most essential profile characteristics in hydrologic studies --retention and detention storage--are functions of soil porosity, water-storage opportunity, and transmission rate of water. Detention storage is measured as noncapillary porosity. Retention storage is measured in terms of additional water of specific retention needed to satisfy capillary requirements. The characteristics of pore space in the soil mass can be easily determined by utilizing the principle of water displacement of air from undisturbed volume samples.

(115) Hursh, C. R., Hoover, M. D., and Fletcher, P. W.
1942. Studies in the balanced water-economy of experimental drainage- areas. Am. Geophys. Union Trans., Part II: 509-517.

In this intensive study of the water balance, estimates of precipitation, ground-water and surface-water flow, and evapotranspiration are the factors used to account for water circulating through a watershed system.

(116) ________ and Lieberman, J. A.
1946. Watershed management in the Southeastern States. USDA Forest Serv. Southeast. Forest Exp. Stn., 7 pp.

Knowledge gained at Coweeta from cutting forest stands, unrestricted logging, mountain farming, and woodland grazing is related to good watershed management in the Southeast.

(117) ________ and Pereira, H. C.
1953. Field moisture balance in the Shimba Hills, Kenya. East Afr. Agric. J. 18(4): l-7.

This article draws on limited observations and field measurements to reconstruct and compare the moisture balance of the grass-covered and depleted Shimba Hills of Kenya with. that under a natural forest. The natural forest, which once occupied the Shimba Hills, is a more desirable cover than grass for maximum-sustained water yield because water additions from mist and dew are greater from the forest.

(118) Johnson, E. A.
1949. Watershed studies producing valuable information. Outdoor News Bull. 3(11): 4.

Research at Coweeta to determine the influence of management practices on streamflow is briefly discussed.

(119) ________
1952. Effect of farm woodland grazing on watershed values in the southern Appalachian Mountains. J. For. 50: 109-113.

The effects of 11 years of grazing cattle on a forested Appalachian watershed are reported. The experiment is described; the effects of grazing on vegetation, soil, and water are presented; and practical implications of grazing mountain watersheds are discussed.

(120) ________ and Dils, R. E.
1956. Outline for compiling precipitation, runoff, and ground water data from small watersheds. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 68, 40 pp.

Procedures used at the Coweeta Hydrologic Laboratory for systematic compilation of data for continuous records of precipitation and stream discharges are described.

(121) ________ and Kovner, J. L.
1954. Increasing water yield by cutting forest vegetation. Ga. Miner. Newsl. 7(4): 145-148.

The authors report on changes in water yield at Coweeta after several different forest treatments.

(122) Johnson, E. A., and Kovner, J. L.
1956. Effect on streamflow of cutting a forest understory. Forest Sci. 2: 82-91.

On Coweeta Watershed 19, the laurel and rhododendron understory (22 percent of total basal area) was cut between December 1948 and March 1949. A 4-inch increase in water yield was achieved the first year after treatment, and the yield increase declined during the next 6 years. This increase was almost evenly divided between the growing and dormant seasons.

(123) ________ and Meginnis, H. G.
1960. Effect of altering forest vegetation on low flows of streams. Comm. Surf. Waters, Gen. Assem. Helsinki. Int. Assoc. Sci. Hydrol. Publ. 51: 257-266.

Large increases in low flows were recorded after mountain hardwood stands were cut on controlled watersheds in North Carolina, and appreciable decreases in flow were recorded after pines were planted on a small Ohio watershed.

(124) Jones, LeRoy
1955. A watershed study in putting a hardwood forest at the Coweeta Hydrologic Laboratory in the southern Appalachian Mountains under intensive management. M. F. Grad. Probl., Univ. Ga. George Foster Peabody Sch. For., 43 pp.

Conversion of a forested catchment at Coweeta from light to intensive management involving single-tree selection, proper road location and construction, and proper logging methods is described. Little increase in stream turbidity was observed. Recommendations for future management are given.

(125) Katana, M. S.
1955. Some comparisons of precipitation, streamflow, and soil on a denuded, a grass-covered, and a forested watershed in the Copper Basin of Tennessee. M.F. Thesis, N.C. State Coll., 124 pp.

Comparison of a denuded, a grass-covered, and a forested watershed at Copper Basin revealed that rainfall was highest on the forested and lowest on the denuded watershed, whereas annual streamflow was highest from the denuded and lowest from the grassed watershed. During the dormant season, flow was highest from the forested and lowest from the grassed watershed. Maximum peak discharge was greatest from the denuded (2,700 c. s. m.), intermediate from the grassed (2,200 c. s. m.), and lowest from the forested watershed (100 c.s.m.). Soils on the three experimental areas did not differ in acidity, calcium, or potassium; but organic matter and phosphorus were lowest on the denuded watershed.

(126) Klawitter, R. A.
1962. Silvics and the wetland forest. Appalachian Sect. Soc. Am. For. Proc., pp. 8-9.

The author discusses the silvical research underway at each of the wetland forest sites at the Charleston Research Center.

(127) Klawitter, R. A.
1965. Woodland drainage in the Southeast. J. Soil & Water Conserv. 20: 181-182.

A brief account is given of woodland drainage practices in the Southeast and their use in altering wet forest sites.

(128) ________
1965. Woodland water management in soil and water conservation. 9th Annu. Meet. Ga. Chapter Soil Conserv. Soc. Am. Proc., 9 pp.

Water management is a reality on about 2 million acres of wetland forest in the coastal plain. Practices must be tailored to fit particular kinds of forests, trees, and soils in the wetlands. Practices must be controlled and well enough understood to enable changes from the production of one forest resource to another, singly or in combination, as the future demands.

(129) ________
1966. Diameter growth of mature loblolly pine unaffected by under-story control. South. Lumberman 213(2656): 154-155.

Diameter growth of 60-year-old loblolly pine on plots where the under-story had been eradicated by prescribed summer fires and growth of similar trees where the under-story was untreated were not meaningfully different. Adequate rainfall during the growing season and advanced age of the trees could explain the study results.

(130) ________
1966. Drainage. 1966 Symp. Hardwoods Piedmont & Coastal Plain Proc., Ga. Forest Res. Counc., Macon, pp. 16-17.

Drainage of wet hardwood lands is a problem because water controls the establishment of hardwoods and their subsequent growth rates.

(131) ________
1966. Early response of pole-sized slash pine to drainage, Southeast. Forest Exp. Stn., U. S. Forest Serv. Res. Note SE-63, 2 pp.

Early results from a drainage study on the Apalachicola National Forest-indicate height growth of pole-sized slash pine may improve considerably within a few days after sandy, wet pine flats are ditched.

(132) ________
1967. Water management in coastal plain woodlands. South. Lumberman 215(2680): 175-177:

Water management is a reality on many acres of wet woodlands in the coastal plain. Man has shown he can shape wetland forest environments to meet his future needs for any of several natural resources by prescribed changes in water regimes, soil properties, and forest vegetation. However, since needs change with time, perhaps the measures we apply to wetland forests should be sufficiently controlled and well enough understood to enable us to change from the production of one forest resource to another as the future demands.

(133) Klawitter, R. A.
1968. Soils information used and needed for woodland production: research findings--organic soils. South. Reg. Tech. Work-Plann. Conf. Coop. Soil Surv. Proc., Clemson Univ., Clemson, S. C., 7 pp.

Large acreages of organic soils in the South are available for woodland production, but landowners need information on these soils to aid in site selection. Criteria that should be included in future surveys of organic soils include botanical origin, stratigraphy, depth, degree of decomposition, wood content, acidity, water sources, and water conductivity. In addition, information is needed on subsoil material, natural vegetation, and fertility.

(134) ________
1969. Wind damages improperly planted slash pine. South Lumberman 218(2709): 24.

The problem of leaning in a-year-old slash pine was studied on the Apalachicola National Forest. The causes were identified as improper planting, wet soil, and wind.

(135) ________
1970. Does bedding promote pine survival and growth on ditched wet sands? Northeast. Forest Exp. Stn., USDA Forest Serv. Res. Note NE-109, 4 pp.

Results from a study of prepared beds for planting slash pine on a wet, sandy flat in Florida were inconclusive. Early growth was improved, but survival was not. Differences between a bedded site and an unbedded site were slight.

(136) ________
1970. Small watershed program--the forest research assessment. Natl. Watershed Congr. Proc. 17: 161-165.

Research to determine the impact of watershed programs authorized by Public Law 566 on the total environment of swamps and bottom lands has been inadequate, A highly intensified research program to develop water management systems that will enhance wetland forest environments and, at the same time, achieve the necessary watershed objectives of both the general public and the local landowners is long overdue.

(137) ________
1970. Water regulation on forest land. J. For. 68: 338-342.

Key objectives of water regulation on wet forest land are to increase timber production and to improve wildlife habitat, range land, and flood control. Each kind of wetland forest--swamps, bottom lands, bays, and wet flats--must receive a prescription suited to local peculiarities, because water regulation works best when properly applied to the task for which it is designed. Measures applied, however, must be well enough understood and sufficiently controlled to enable changes in design and shifts in productivity from one resource use to another as the future demands.

(138) Klawitter, R. A., Stubbs, Jack, and Johnson, F. M.
1963. Tests of Arasan 75-Endrin 50W rodent repellent on Shumard and swamp chestnut oak acorns. Southeast. Forest Exp. Stn., U. S. Forest Serv. Res. Note SE-4, 2 pp.

Arasan 75-Endrin 50W® is an effective rodent repellent only when alternate food supplies are readily available.

(139) ________ and Young, C. E., Jr.
1965. Forest drainage research in the coastal plain. J. Irrig. & Drain. Div., ASCE, 91(IR3) Proc. Pap. 4456: l-7.

Preliminary information is presented on expected increases in productivity of drained wetland forest soils. Results are based on a study in northwest Florida and a survey in coastal North Carolina. Increases in soil productivity were evaluated in terms of height and volume growth of pine trees.

(140) Knipling, E. B.
1963. Investigation of the Schardakow Method for the measurement of diffusion pressure deficit. M. S. Thesis, Duke Univ. Sch. Bot., 72 pp.

Improvement of a simple method for measuring the water potential in leaves is described, and the relationship between water potential and water deficit in dogwood and sourwood is shown.

(141) ________
1967. Effect of leaf aging on water deficit-water potential relationships of dogwood leaves growing in two environments. Physiol. Plant. 20: 65-72.

The relationships between water deficit and water potential were not the same for dogwood leaves of different ages or for leaves of the same age but growing in different environments. With leaf aging, particularly under high light intensity and dry environmental conditions, the relationships shifted to progressively lower water potentials for a given water deficit, increased dry weight, decreased cell-wall elasticity, and decreased osmotic potentials. The-lack of constancy in the relationships reduces the usefulness of water deficit or relative turgidity as an estimator of water potential.

(142) ________
1967. Measurement of leaf water potential by the dye method. Ecology 48: 1038-1041.

The dye method for measuring leaf water potential is simple, inexpensive, and suitable for both laboratory and field work. Leaves are immersed in a graded series of solutions, and the solution which neither gains nor loses water is assumed to have a water potential equal to that of the leaf.

(143) Knipling, E. B., and Kramer, P. J.
1967. Comparison of the dye method with the thermocouple psychrometer for measuring leaf water potentials. Plant Physiol. 42: 1315-1320.

The dye method for measuring water potential was compared with the thermocouple psychrometer method and found to be useful for measuring leaf water potentials of forest trees and common laboratory plants.

(144) Kovner, J. L.
1955. Changes in streamflow and vegetation characteristics of a southern Appalachian Mountain watershed brought about by a forest cutting and subsequent natural regrowth. Ph. D. Thesis, State Univ. N. Y. Coll. For., Syracuse, 245 pp.

The first year after a 40-acre watershed at Coweeta was clearcut, water yield increased 15.11 inches; this increase declined as the coppice stand regrew. A multiple regression showed a highly significant correlation between seasonal increases in streamflow and time. It was estimated that increases would be less than 2 inches in 25 years and negligible in 40 years. Increases did not appear related to amount of precipitation during May-Sept. and Oct. -Dec. but were related to precipitation in the Jan. -April period. By the 12th year after cutting, basal area had increased to 51.6 square feet per acre, about half of the basal area of a projected normal stand, but total annual production of foliage did not differ significantly between treated and control areas.

(145) ________
1957. Evapotranspiration and water yields following forest cutting and natural regrowth. Soc. Am. For. Proc. 1956: 106-110.

The effects on stream regimen of cutting and later regrowth of a hardwood forest in the southern Appalachians are reported. Changes in stand density are compared with changes in streamflow and P - RO (precipitation minus runoff).

(146) ________
1957. Evapotranspiration in forest stands of the southern Appalachian Mountains. Bull. Ga. Acad. Sci. 15(3): 80-85.

The author presents a method of estimating evapotranspiration by the water balance equation P - Ro = Ev, where P = precipitation, Ro = streamflow, and Ev = evapotranspiration, and discusses the relationship between estimated evapotranspiration and elevation.

(147) ________ and Evans, T. C.
1954. A method for determining the minimum duration of watershed experiments. Am. Geophys. Union Trans. 35: 608-612.

A simple graphic solution is described for approximating the length of time required to detect significant differences between treatments on experimental watersheds.

(148) Lieberman, J. A.
1947. Water resource and watershed management research in the Southeast. Am. Waterworks Assoc. J. 39(5): 443-454.

The facilities, research program, and research findings at Coweeta Hydrologic Laboratory are reviewed.

(149) ________ and Fletcher, P. W.
1947. Further studies of the balanced water cycle on experimental watersheds. Am. Geophys. Union Trans. 28: 421-424.

Maintaining a chronological account or balance of the components of the water resource on a watershed is frequently valuable in hydrology studies. In this paper, a time period for studying this balance is described: the period between the times of maximum watershed storage at the end of each dormant season. Changes in ground-water storage are thus taken into account, and, by choosing the beginning and ending points of the year at times of field capacity, changes in water storage in the soil mass are minimized.

(150) ________ and Hoover, M. D.
1948. The effect of uncontrolled logging on stream turbidity. Water & Sewage Works 95(7): 255-258.

The effects of the unrestricted logging of Watershed 10 at Coweeta on soil erosion and stream turbidity are reported. The authors stress the need for improvements in the design, location, and maintenance of roads and in logging methods.

(151) ________ and Hoover, M. D.
1948. Protecting quality of stream flow by better logging. South. Lumberman 177(2225): 236-240.

The authors report on the results of unrestricted logging on Watershed 10 at Coweeta and present suggestions for road location and maintenance and logging practices which will protect the soil and water resource.

(152) ________ and Hoover, M. D.
1951. Stream-flow frequency changes on Coweeta experimental watersheds. Am. Geophys. Union Trans. 32: 73-76.

Frequency distribution curves of mean daily discharge from treated and control watersheds at Coweeta are compared for the prior- and post-treatment periods. Conclusions are drawn about the effect of the treatments on the regimen of daily stream-flow and about the practicability of using frequency distribution curves to show streamflow changes brought about by experimental land-use treatments.

(153) Meginnis, H. G.
1956. Forestry and water resource development in the South. Forest Farmer 16(2): 12-13, 28, 30-32.

This paper discusses four prospective developments which, because of their effect on water supply, will affect southern forestry in the years ahead. The developments are intensive development and use of valley lands, construction of impoundments to store and regulate streamflow, growing industrial demands for water, and public efforts to clean up streams and combat pollution.

(154) Meginnis, H. G.
1956. Principles of watershed management based on current research. Watershed Manage., Interstate Comm. Potomac River Basin, pp. 15-19.

Watershed management as the integrated management of all renewable resources of a drainage basin is discussed. Principles of watershed management based on current research are recounted, premises that underlie and further define watershed management are outlined, and some important research needs are listed.

(155) ________
1959. Increasing water yields by cutting forest vegetation. Symp. Hannoversch-Münden. Int. Assoc. Sci. Hydrol. Publ. 48: 59-68.

The author discusses volume and timing of yield increases produced by clearcutting with annual cutting of regrowth, clearcutting with coppice regrowth allowed, and clearcutting of understory vegetation. Despite indications afforded by these experiments, a more complete knowledge of water requirements of cover and of plant-soil-climatic factors which govern evapotranspiration is required before yield increases caused by cover manipulations can be predicted accurately,

(156) ________
1960. Watershed management research--challenging career for young scientists. Ames For. 47: 20-24.

The author outlines present knowledge in the field of watershed management, needs for further research, and opportunities for specialists in many disciplines who might wish to enter this field.

(157) Merrick, E. T., and Johnson, E. A.
1952. Mountain water. Am. Forests 58(10): 30-32, 38.

Objectives of the research program at Coweeta and studies of stream temperature and interception are briefly discussed.

(158) Metz, L. J.
1952. Calcium content of hardwood litter four times that from pine; nitrogen double. USDA Forest Serv. Southeast. Forest Exp. Stn. Res. Notes 14, 2 pp.

Hardwood litter returned greater amounts of calcium and nitrogen to the soil than did pine litter.

(159) ________
1952. Weight and nitrogen and calcium content of the annual litter fall of forests in the South Carolina Piedmont. Soil Sci. Soc. Am. Proc. 16: 38-41.

Weight of leaves, twigs, bark, and fruit fall is presented for pine, pine-hardwood, and hardwood stands. Leaf fall ranged from 2,900 pounds per acre in a 30- to 40-year-old shortleaf stand to 4,500 pounds per acre in a 25-year-old loblolly pine plantation. Leaf fall for hardwood stands ranged from 3,600 to 4,100 pounds per acre. Hardwoods returned twice as much nitrogen, three times as much magnesium, and five times as much calcium to the soils as did pine stands.

(160) Metz, L. J.
1954. Forest floor in the Piedmont region of South Carolina. Soil Sci. Soc. Am. Proc. 18: 335-338.

The annual litter fall, weight of the forest floor, and incorporation of organic matter in the surface foot of mineral soil are reported for three pine, three pine-hardwood, and three hardwood stands in the South Carolina Piedmont. The forest floors are classified as to humus type, and some practical applications of the information to forest management are discussed.

(161) ______
1958. The Calhoun Experimental Forest. USDA Forest Serv. Southeast. Forest Exp. Stn., 24 pp.

The research program at the Calhoun Experimental Forest is discussed, with emphasis on problems concerning forests, soils, and water.

(162) ______
1958. Moisture held in pine litter. J. For. 56: 36.

Litter under a 12-year-old plantation of pine in the Piedmont held a maximum of 0.09 inch of moisture and a minimum of 0.01 inch. Drying rapidly removed moisture so that equilibrium moisture conditions were reached 11 days after a rain.

(163) ______
1959. The description and measurement of the forest floor. Tech. & Methods Meas. Understory Veg. Symp. Proc. 1958: 105-113. Publ. jointly by USDA Forest Serv. South. Forest Exp. Stn. and Southeast. Forest Exp. Stn.

Nomenclature of the forest floor is discussed, and methods of measuring components and characteristics of the forest floor are described.

(164) ______
1960. The de la Howe old-growth forest in Piedmont shortleaf pine. J. For. 58: 807-809.

The author describes the history and condition of the de la Howe forest and emphasizes the value of such bench marks for study of soil-plant relations, forest-disease impacts, and forest growth potential.

(165) ______
1960. Hydrologic properties of southern forest soils. South. Forest Soils. La. State Univ. Sch. For., 8th Annu. For. Symp. Proc. 1959: 19-24.

Soil properties which affect movement and storage of water are discussed, and the importance of maintaining favorable hydrologic properties is stressed.

(166) Metz, L. J., and Douglass, J. E.
1959. Soil moisture depletion under several Piedmont cover types. U. S. Dep. Agric. Tech. Bull. 1207, 23 pp.

Data are presented on soil moisture regimen under pine and pine-hardwood forest cover, old-field (broomsedge) vegetation, and bare soil. Forest types depleted soils to 66 inches at about the same rate, regardless of species, whereas moisture loss from broomsedge grass and bare plots was limited to the surface 30 inches. The pattern of withdrawal and recharge of soil moisture is cyclic; recharge begins in the late fall or winter and depletion begins with the start of the growing season. Moisture loss from barren and vegetated soils is related to depth; with increasing depth, the rate of moisture loss decreases.

(167) ________ Lotti, Thomas, and Klawitter, R. A.
1961. Some effects of prescribed burning on coastal plain forest soil. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 133, 10 pp.

From 1946 to 1956, a study was made of the effect of prescribed burning on soil beneath loblolly pine stands growing in the lower coastal plain of the Southeast. Annual and periodic fires for the lo-year period had no significant influence on physical properties of the soil. However, mineral elements, nitrogen, and organic matter tended to increase in the surface 4 inches of burned plots.

(168) Munns, E. N.
1947. Forest hydrology in the Appalachians. J. Soil & Water Conserv. 2: 71-76.

The author discusses the beneficial effects of the forest on regulating streamflow, as opposed to other forms of land management, and also gives a general discussion of watershed experiments at the Coweeta Hydrologic Laboratory.

(169) ________
1948. Our forests and watersheds. Sci. Mon. 67(5): 347-354.

The research facilities, program, and findings at Coweeta Hydrologic Laboratory are summarized.

(170) Murphy, C. E., Jr.
1970. Energy sources for the evaporation of precipitation intercepted by tree canopies. Ph. D. Diss., Duke Univ., 260 pp.

The total energy balance of individual tree leaves was measured in a controlled environment chamber and simulated for a wide range of conditions on a digital computer. This study demonstrated the use of existing engineering theory and parameters for estimating leaf energy exchanges. Water loss frcm an externally wet leaf was always greater than from an unwet transpiring leaf because the cool evaporating surface could absorb extra heat from the air and because a given amount of energy was more efficient in evaporating surface water than transpired water. Evaporation was shown to occur during precipitation. This evaporation rate can account for only part of the slope of the interception equation derived at Coweeta for eastern hardwood stands.

(171) Nelson, T. C.
1955. Chestnut replacement in the southern highlands. Ecology 36: 352-353.

Seventeen 1/5-acre plots were established in 1934 prior to the onset of chestnut blight and were resurveyed in 1941 and 1953. Chestnut decreased from 41 to 1 percent of total basal area from 1934 to 1953. Basal area of yellow-poplar, black oak, and scarlet oak increased while other species remained approximately the same or decreased. Invasion of openings was primarily by sourwood, cucumber magnolia, sweet birch, and eastern hemlock.

(172) ________ and Johnson, E. A.
1954. Applying unit area control to watershed management. J. For. 52: 130.

The authors outline the potential application of unit area control to a watershed for integrated management of timber and water resources.

(173) Olson, D. F., Jr., and Hoover, M. D.
1954. Methods of soil moisture determination under field conditions. USDA Forest Serv. Southeast. Forest Exp. Stn. Pap. 38, 28 pp.

Field methods of determining soil moisture are discussed in detail.

(174) Patric, J. H.
1963. Forest experiment demonstration area on trail. Appalachian Trailway News 24(2): 21.

A new experiment in multiple use management at Coweeta is visible to hikers on the Appalachian Trail.

(175) ________ Douglass, J. E., and Hewlett, J. D.
1965. Soil water absorption by mountain and piedmont forests. Soil Sci. Soc. Am. Proc. 29: 303-308.

In the southern Appalachians and the South Carolina Piedmont, absorption of soil water by tree roots in the top 20 feet of soil was determined from moisture and matric potential measurements under 50- by 50-foot, plastic-covered plots. The data indicate that, where soil matric potential is kept low by frequent rainfall, most transpired water comes from densely rooted surface soil, whereas soil water well beyond rooting depths-returns to the surface during long periods without rain.

(176) Pitcher, K. A.
1955. The influence of cove-site vegetation on streamflow and soil moisture in the southern Appalachians. M.F. Thesis, N.C. State Coll., 99 pp.

Cove-site vegetation was killed on one watershed, while another forested watershed was retained as a control. Soil characteristics, precipitation, streamflow, stream temperature, and soil moisture were measured on each catchment. Stream temperatures were significantly increased by the treatment. In the treated cove, moisture content in the 5-foot soil depth was 3.5 inches greater than in the untreated cove. Differences in moisture content became apparent around the first of July and increased through August.

(177) Schreuder, H. T., and Swank, W. T.
1971. A comparison of several statistical models in forest biomass and surface area estimation, pp. 123-136. In Forest biomass studies. Univ. Maine, Life Sci. & Agric. Exp. Stn., Misc. Publ. 132.

The squared correlation and log likelihood techniques are discussed and used to evaluate statistical estimation models for eastern white pine biomass and surface area data. Three a priori linear models are considered: (1) an unweighted untransformed model, (2) a weighted untransformed model, and (3) a log-log transformation model,

(178) Sluder, E. R.
1958. Mountain farm woodland grazing doesn't pay. USDA Forest Serv. Southeast. Forest Exp. Stn. Res. Notes 119, 2 pp.

The general results of the mountain farm experiment at Coweeta are presented.

(179) Smalley, G. W.
1956. Some criteria for determining unit area control in watershed management on municipal and industrial watersheds in the southern Appalachians. M. S. Thesis, Mich. State Univ. Agric. & Appl. Sci., 99 pp.

The results of applying unit area control to integrated management of water and timber resources at Coweeta are presented. Unit areas delineated on the basis of aspect, slope, soil depth, and vegetation were applied on a small-unit watershed to determine practicality of the approach. Unit area control provides a satisfactory approach to integrated management of timber and water if both hydrologic and silvicultural characteristics are considered, but knowledge of the interrelationships between plants, soil, and water is essential before management practices can be prescribed for unit areas.

(180) Snyder, J. E., and Hursh, C. R.
1938. Low cost erosion control on highway slopes in Southeastern United States. Highw. Res. Board Proc., Part 1: 213-215.

Important factors in stabilizing exposed highway slopes are the stability, moisture, and fertility of the soil. Steepness and length of slope, alternation of freezing and thawing, and the physical nature of soil affect soil stability. Lack of moisture because of over-drainage and direct exposure to solar radiation is also a basic cause of failure in roadside naturalization. Many road cuts expose infertile subsoil and parent-soil material which are difficult to vegetate. Use of mulches of local organic materials is a suitable means for ameliorating unfavorable site conditions.

(181) Southeastern Forest Experiment Station
1948. Watershed management research--Coweeta Experimental Forest. USDA Forest Serv. Southeast. Forest Exp. Stn., 45 pp.

This is the first guidebook to Coweeta and is designed to acquaint the reader with the laboratory, the research methods, program, findings, and future research plans.

(182) Southeastern Forest Experiment Station
1964. Improvements at Coweeta. USDA Forest Serv. Southeast. Forest Exp. Stn., 16 pp.

This report covers improvements and research at Coweeta since October 1962, when the accelerated Public Works program began at the Laboratory. Improvements consisted of construction of a road and bridge in the administration area, a 20,000-gallon gravity water system, a three-bedroom dwelling for forest superintendents, a 40- by 60-foot metal warehouse for storage, a 40- by 100-foot wet lab, and an extension to the existing office building, as well as repairs made on 18 weirs and the reworking of 25 miles of neglected roads and trails. Research activities included installation of a 356-acre multiple-use watershed and clearcutting of two forested watersheds to determine the effects of such cutting on water yield.

(183) ________
1968. Visitor's guide - Coweeta Hydrologic Laboratory. USDA Forest Serv. Southeast. Forest Exp. Stn. [In-Serv. leafl.]

This leaflet enables the reader to make a self-guided tour of the Coweeta Hydrologic Laboratory.

(184) Striffler, W. D.
1957. The soil moisture regime under native hardwoods at five elevations in the southern Appalachians. M. F. Thesis, Univ. Mich. Sch. Nat. Resour., 93 pp.

At ridgetop sites at five different elevations, data were collected for 1 year on timber stand and basal area, crown densities, litter weights and types, soil moisture, soil type and physical properties, and root densities. Results indicate that, within certain horizons, soil moisture depletion rates vary with elevation, but average depletion rates for the entire profile and total water losses do not vary with elevation.

(185) Stubbs, Jack
1962. Wetland forests. Forest Farmer 21(11): 6-7, 10-13.

Opportunities and problems of managing wetland forests in the Atlantic Coastal Plain are discussed.

(186) Swank, W. T.
1968. The influence of rainfall interception on streamflow. Hydrol. Water Resour. Manage. Conf. Proc. Clemson Univ. Water Resour. Res. Inst. Rep. 4, pp. 101-112.

The data presented provide evidence that interception loss is a major hydrologic process which reduces the quantity and alters the timing of streamflow from watersheds in the southern Appalachians when cover types are changed from mature mixed hardwoods to eastern white pine. Differences in interception loss between loblolly pine and mature hardwoods in the Piedmont of South Carolina are discussed.

(187) Swank, W. T., and Helvey, J. D.
1970. Reduction of streamflow increases following regrowth of clearcut hardwood forests, pp. 346-360. In Symposium on the results of research on representative and experimental basins. UNESCO-AH-IS Publl. [Assoc. Int. Hydrol. Sci.] 96.

The mature hardwood forest on a Is-hectare catchment at the Coweeta Hydrologic Laboratory was initially clearcut in 1939. The first year following cutting, streamflow increased 360 mm; As the even-aged coppice stand regrew, annual streamflow increases approached pretreatment levels as a linear function of the logarithm of time. The watershed was clearcut again in 1962, and streamflow response for the year following cutting was 380 mm. In striking contrast to the first cutting, streamflow increases have diminished at a much faster rate, and it appears that annual water yield will return to pretreatment levels after just 16 years of forest regrowth following the second cutting. The difference in the measured response is attributed primarily to a more rapid recovery of vegetation in the second treatment period.

(188) ________ and Miner, N. H.
1968. Conversion of hardwood-covered watersheds to white pine reduces water yield. Water Resour. Res. 4: 947-954.

Mixed mature hardwoods were cleared from two experimental watersheds in the southern Appalachians, and the areas were planted with eastern white pine in 1956-57. Once the pine crowns began to close, streamflow steadily declined at a rate of 1 to 2 inches per year. By 1967, water yield from a lo-year-old pine stand on a south-facing watershed was 3.7 inches less than the expected water yield from the original hardwood forest. Most of the reduction in water-yield occurred during the dormant season and was attributed mainly to greater interception loss from white pine than from hardwoods. Because interception differences increase as white pine matures, an even greater reduction in streamflow is expected.

(189) Swift;' L. W., Jr.
1960. The effect of mountain topography upon solar energy theoretically available for evapotranspiration. M. S. Thesis, N. C. State Coll., 76 pp.

A study was made to determine why results from formulas for estimating evapotranspiration losses do not agree with hydrologic measurements made on small watersheds. Study of irradiation intensities on steep north- and south-facing watersheds showed that these watersheds should receive an equal amount of radiation during the growing season; during the dormant season, the south-facing catchment should receive a much greater amount of solar radiation. Although slope and aspect do affect the quantity of solar irradiation for small watersheds, corrections for energy receipt do not completely answer the problem of why hydrologic and energy balance methods of estimating evapotranspiration do not agree.

(190) Swift, L. W., Jr., and Messer, J. B.
1971. Forest cuttings raise temperatures of small streams in the southern Appalachians. J. Soil & Water Conserv. 26: 111-116.

Stream temperatures were measured during six forest-cutting treatments imposed on 23- to 70-acre watersheds in the southern Appalachian Mountains. Where forest trees and all understory vegetation were completely cut, maximum stream temperatures in summer were raised from the normal 66" F. up to 73° or more. Some extreme treatments raised temperatures over 12" above normal. Where streambank vegetation was uncut or had regrown, summer maximums were unchanged or reduced from levels found under uncut mature hardwoods. Increases in stream temperature were judged to degrade water quality and constitute thermal pollution because, after each clearcut, water temperatures exceeded optimum levels for trout habitat.

(191) Tebo, L. B., Jr.
1955. Effects of siltation, resulting from improper logging, on the bottom fauna of a small trout stream in the southern Appalachians. Prog. Fish-Cult. 55: 64-70.

Siltation resulting from improper land-use practices is regarded as one of the most important factors contributing to a reduction in the acreage of desirable fishing waters. This report presents quantitative data regarding the effect of siltation on bottom fauna of trout streams in the southern Appalachians.

(192) Trousdell, K. B., and Hoover, M. D.
1955. A change in ground-water level after clearcutting of loblolly pine in the Coastal Plain. J. For. 53: 493-498.

Ground-water observation wells were dug in adjacent compartments of old-growth loblolly pine-hardwood in the Coastal Plain of North Carolina. After one compartment was clearcut, the water table rose to higher levels for the remainder of the growing season than it did beneath a selectively cut forest stand. A ground-water profile, determined from a transect of 10 temporary wells spaced at l-chain intervals from the clearcut into a selectively cut stand, showed water tables to be highest beneath clearcut strips and lowest beneath selectively cut stands.

(193) USDA Forest Service
1953. Waters of Coweeta. Agric. Inf. Bull. 117, 22 pp.

The results of 20 years of streamflow studies at Coweeta are highlighted. Text and pictorial illustrations are borrowed from a documentary film with the same title.

(194) Waggoner, P. E., and Hewlett, J. D.
1965. Test of a transpiration inhibitor on a forested watershed. Water Resour. Res. 1: 391-396.

The glyceryl half-ester of decenylsuccinic acid (G1OSA) closes tree stomata when sprayed directly upon the undersides of leaves. At Coweeta, a 12 percent reduction in transpiration might be detected as a significant increase in streamflow. Two sprays of 50 pounds of G1OSA in water applied to 30 acres of one watershed from a helicopter produced little deposit on the undersides of leaves and no clear evidence of stomatal closure. Observed increases in streamflow were statistically insignificant.

(195) Whelan, D. E.
1957. Effects of land use on streamflow. Ala. Acad. Sci. J. 29(4): 55-60.

Present knowledge of the effects of land use and treatment on streamflow is summarized. The basic concepts of land use and ground-water hydrology are discussed in order to show how soil and vegetal cover influence the disposition of precipitation.

(196) Williams, J. G.
1954. A study of the effect of grazing upon changes in vegetation on a watershed in the Southern Appalachian Mountains. (Abstr.) J. For. 52: 867.

Growth and destruction of vegetation during grazing by cattle on a forested mountain watershed are described.

(197) ________
1954. A study of the effect of grazing upon changes in vegetation on a watershed in the southern Appalachian Mountains. M. S. Thesis, Mich. State Univ. Agric. & Appl. Sci., 138 pp.

The effect of grazing on vegetation of a 145-acre forested watershed at Coweeta is reported. For 11 years, six cattle grazed an average of 4 months each year. By the end of the first season, practically all herbaceous forage and much of the hardwood understory had been utilized. After the second season, supplemental feeding was required. The effect of grazing was particularly severe in the cove-hardwood site. Insufficient forage was present in the dense hardwood stands to make grazing profitable, and young trees of desirable species were damaged by grazing.

(198) Young, C. E., Jr.
1961. Drainage research on forest wetlands in the Southeast. La. State Univ., ARS-SCS Workshop Land Leveling for Drain. & Irrig. Proc. 1961: 87-88.

The wetland problem areas in the Southeast, current research underway, and plans for the future are briefly discussed.

(199) Young, C. E., Jr.
1964. Water management: key to wetland forest improvement in the Southeast. (Abstr.) Assoc. South. Agric. Work. Proc. 1964: 61-62.

The author discusses problems associated with managing wetland forests, preliminary research results on improving wetlands through drainage, and research activities of the Wetland Improvement Project in Charleston, South Carolina.

(200) ______
1966. Growth trends of loblolly pine on two drained wetlands. South. Lumberman 213(2656): 160-161.

Diameter and height growth of lo-year-old loblolly pines were measured for 2 years on a sandy ridge bay and a heavy clay "Carolina" bay near Charleston, South Carolina. Measurements were related to amounts of precipitation and water-table levels. Growth was better during a wet year when water-table levels were higher than during a dry year when lower water-table levels prevailed. Growth was also considerably better on the heavy soil than the light soil.

(201) ______
1966. Soil sampling small wetland forest plots in the coastal plain. Southeast. Forest Exp. Stn., U. S. Forest Serv. Res. Note SE-59, 2 pp.

The variability of soil properties creates problems in soil sampling in the lower coastal plain, where little information is available to guide study designs. This study shows the number of sampling locations on each of the test plots needed to estimate the mean of various physical properties within 5 percent for two probability levels and two common wetland soils. Scientists faced with a soil sampling problem on similar wetlands soils will now have a starting point to determine the magnitude of sampling needed in their work.

(202) ______
1966. Waterbalance on a forested watershed in the flatwoods. (Abstr.) Assoc. South. Agric. Work. Proc. 1966: 69.

Hydrologic data collected from a 400-acre watershed will be used to make short term estimations of evapotranspiration, evaluate existing groundwater and surface water supplies, and provide design criteria for water management structures.

(203) ______
1967. Streamflow- -important factor in forest management. South. Lumberman 215(2680): 109-l 10.

Streamflow records indicate that the stofmflow volume produced from a forested watershed in the lower coastal plain is highly dependent on the storage potential of the watershed prior to rainfall. On the average, this watershed produces more stormflow than forested watersheds in the mountains and Piedmont. However, streamflow is intermittent, with no-flow periods as long as 1 to 2 months occurring each year.

(204) Young, C. E., Jr.
1969. Water table, soil moisture, and oxygen diffusion relationships on two drained wetland forest sites. Soil Sci. 107: 220-222.

Statistical models that express the relationship between (1) depth to water table and soil-moisture content at 6 to 18 inches and (2) depth to water table and oxygen-diffusion rate at 12 inches have been developed for two wetland forest sites. Some of these models agreed with data published in the literature, but others did not. The coefficients of determination were reasonably high for all the relationships. The models have not been verified for other areas. The soil types sampled included Bayboro clay loam and Plummer loamy sand.

(205) ______
1970. Effect of cultural practices on water resources. Am. Soc. Civ. Eng., Soc. & Ecol. Aspects Irrig. & Drain. Spec. Conf. 1970: 77-90.

Between 1 and 2 million acres of wetland forests have been drained in the past 20 to 25 years. With today's interest in environmental degradation, facts are needed to determine whether certain cultural practices are harmful to water resources, wildlife, plant communities, and stream and estuarine biology. A study is planned on the Apalachicola National Forest in northwest Florida to obtain some of these facts. The study will run 7 to 10 years and will use the paired watershed approach for determining changes in water resources.

(206) ______ Auld, I. D., Jr., and Gaskins, Rudolph
1962. An efficient process for making wire marking pins. USDA Forest Serv. Tree Plant. Notes 53: 25-26.

A method is described which reduces manufacturing time for wire marking pins by one-half to three-quarters.

(207) ______ and Henderson, J. E.
1965. A method for sealing soil moisture access tubes. Soil Sci. 99: 213-214.

Access tubes sealed with a rubber stopper that has been secured with nails and coated with a nonhardening gasket sealer will withstand pressures up to at least 6 pounds per square inch without leaking. Necessary materials are listed, and the sealing process is described step by step.

(208) ______ and Henderson, J. E.
1966. An overflow system for a standard U. S. Weather Bureau evaporation pan. Southeast. Forest Exp. Stn., U. S. Forest Serv. Res. Note SE-60, 2 pp.

This Note describes an economical and easily installed overflow system that increased the storage capacity of a standard U. S. Weather Bureau evaporation pan by 2 inches.

(209) Young, C. E., Jr., and Klawitter, R. A.
1968. Hydrology of wetland forest watersheds. Hydrol. Water Resour. Manage. Conf. Proc. Clemson Univ. Water Resour. Res. Inst. Rep. 4, pp. 29-38.

Preliminary results from a 400-acre wetland watershed on the Santee Experimental Forest showed that average annual storm runoff was approximately twice that from forested watersheds in the Piedmont and mountains. Furthermore, during wet periods, peak runoff rates were double those computed for the watershed by an accepted drainage formula. Measured evapotranspiration was slightly greater than Thornthwaite's potential ET.

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Douglass, James E.
1972. Annotated bibliography of publications on watershed management by the Southeastern Forest Experiment Station, 1928-1970. Southeast. Forest Exp. Stn., USDA Forest Serv. Res. Pap. SE-93, 47 pp.

This bibliography contains annotated citations to all publications by the Southeastern Forest Experiment Station on watershed management from 1928 to 1970. Citations are indexed by subject category.

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The Forest Service, U. S. Department of Agriculture, is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. **Through** forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it **strives**— as directed by **Congress**— to provide increasingly greater service to a growing Nation.